SAFE MAINTENANCE OF FISHING VESSELS

Introduction

Fishing is one of the most dangerous jobs in the world. The International Labour Organisation (ILO) and Food and Agriculture Organisation (FAO) estimate that 7% of all fatalities at work occur in the fishing industry, even though it accounts for less than 1% of the worldwide workforce.

There were approximately 7,460 UK-registered fishing vessels in 1999; 370 accidents and incidents involving these vessels were reported during that year. Machinery damage was responsible for 63% of the accidents [1]. Cumulative data from 1994 to 1999 on UK-registered fishing vessels revealed that machinery damage was found to be the most common cause of accidents on fishing vessels, contributing about 64% of all accidents. This can be attributed to several factors including poorly maintained equipment, out-of-date equipment, incorrect operation, equipment age and lack of automation [1]. Although most machinery failures do not threaten the vessel or the lives of the crew, in combination with other factors such as bad weather or strong currents, the consequences may be disastrous.

Maintenance of the vessel includes surveys and repairs in dry-dock undertaken by ship yard workers and contractors, and minor and routine repairs undertaken by the ship's crew at sea or in wet dock. Major maintenance operations are normally performed when the catch is unloaded, or in the off-season when the vessel is in port, and may include, for example, washing out the cold storage hold, washing the vessel, unloading old equipment, greasing the equipment, repairing any damage noticed while fishing, and tune-ups. Minor routine maintenance operations may be performed in the port by the fishermen (particularly in small fishing vessels). Specialised carpenter, mechanic, hydraulic, electronic and electricity operations are normally performed by individual technicians, maintenance companies, suppliers or dealers. Full shaft line repairs and propeller works may be performed by specialised companies. Dry-dock operations may include hull works (including hull plate replacement), high-pressure washing, water blasting, shot-blasting and painting services. Onboard emergency repairs are performed at sea by the fishermen or by technicians (particularly in large vessels).

The dangers met by fishermen at sea have been studied in more depth, but little information is available on accidents affecting fishermen while the vessel is in port, i.e. during dockside activities. Data on 5,074 of this kind of accidents registered in France between 1996 and 2005 indicate that 21% of these accidents were sustained during vessel maintenance [2].

Norwegian statistics on occupational accidents during 2008 showed a disturbingly high share of accidents involving personnel on board fishing vessels. In some cases, risk assessment and safety evaluation of work operations were considered inadequate [3].

A vessel's crew may be at risk of accidents and ill-health or even death as a result of lack of, or inadequate, maintenance or during maintenance:

- Severe vessel damage/loss or loss of life may result from the failure or malfunctioning of critical equipment during fishing operations at sea;
- Accidents and illness may occur during emergency repair operations at sea, during routine maintenance activities in port or during major dry-dock maintenance operations (for example, major repairs to the deck and hull).

Emergency repairs carried out at sea are particularly risky, due to possible adverse weather conditions, the movements of the vessel, the need to complete the repairs quickly, the lack of adequate tools or lifting / transportation equipment, and even the lack of necessary skills.

Figure 1: Clogged sea chest

Courtesy of INCDPN – The National Research and Development Institute on Occupational Safety, Romania

Possible consequences of inadequate maintenance on fishing vessels

Accident data involving fishing vessels report casualties due to onboard equipment malfunction or failure [4]. Equipment failure or malfunction may lead to serious accidents while at sea. Some examples are listed below.

Equipment failure or malfunction	Possible consequences
Engine or gearbox (propulsion equipment) or other machinery failures in combination with bad weather or strong currents	Foundering/flooding, grounding, capsizing, collisions and contacts
Burst pipes, fittings working loose, leaking glands and sprung planks	Foundering/flooding
Oil or fuel coming into contact with hot exhausts in the engine room, leaking fuel or oil	Fire and explosion
Damage to heating and cooking stoves (propane heater), liquid propane gas (LPG)	Fire and explosion, suffocation
Electrical faults	Fire and explosion
Weakening of the hull structure of the vessel and deck fittings loosened due to heavy weather	Foundering/flooding
Batteries in poor condition	Fire and explosion
Corroded pipes, loose fittings, worn seals	Foundering/flooding
Bilge level alarms not fitted or working	Grounding

Equipment failure or malfunction	Possible consequences
Sea inlet valves seized or out of reach	Flooding cannot be stopped
Worn emergency water pumps	Flooding cannot be stopped
Watertight doors defective	Flooding cannot be stopped
Fire extinguishers inoperative	Fire cannot be stopped
Malfunctioning of the CO_2 bottle and the 'auto head' in the life jackets	Risk of drowning
Malfunctioning of the HRU hydrostatic release in the inflatable life raft	Risk of hypothermia or drowning
Emergency position indicating radio beacon (EPIRB) not working properly	Inability to communicate location in an emergency
Emergency electrical fire pump defective	Fire cannot be stopped
Fire-detection and alarm systems defective	Fire may be detected too late
Navigation lights inoperative	Collision
Malfunctioning of the navigation equipment	Grounding
Inoperative VHF-FM radios (radio communications)	Inability to communicate in an emergency

- On 19 January 2008 a fire broke out on board the 33 metre long UK registered fishing vessel Shark. Initial attempts by the crew to fight the fire were hampered by a loss of fire-fighting water when electrical supplies were burnt through and because the emergency fire pump was defective [5].
- A 20 metre wooden fishing vessel suffered an engine room fire, thought to be caused by a fault in the electrical system. The emergency engine and fuel shut-off systems did not operate correctly, and the engine had to be stopped with the use of a rope, to stop it fouling the propeller. The fire was severe, and with dense smoke escaping from the engine room the skipper sent a 'Mayday' before evacuating his crew to the life raft [6].
- The Solway Harvester began to take water into her fish hold through open ice scuttles. The investigation found that her bilge alarm was not functioning before the accident. It also found that the bilge pumping arrangements were not working as intended [7].
- The Marina Random Harvest began flooding and the leak could not be stopped. Emergency bilge pumping arrangements managed to contain the flooding. The cause of the leak was found to be a failure of a 25 mm brass through-hull fitting to the toilet seawater inlet, which had broken close to its flange. The fitting had failed because of dezincification, which had probably been accelerated by stray electric currents [8].

Hazards during maintenance operations on board fishing vessels (emergency repairs and in-port maintenance)

Maintenance operations may imply activities in the engine room, where space is restricted and the air may be polluted by the exhaust gases during engine trials. The environment can be very noisy and hot pipes may also constitute a hazard. Fire and explosions may be caused by flammable and combustible cleaning solvents such as methyl ethyl ketone (MEK), mineral spirits and diesel fuel/oil. Repairs around electrical equipment in wet locations have an increased risk of giving rise to electric shock or electrocution due to exposed energised electrical parts, open lighting parts or damaged insulation on power cords. Slippery working surfaces and items such as greasy ladders and decks, as well as loose equipment, hoses and vessel structures may pose slip and trip hazards.

Examples of injuries that may occur during maintenance operations on fishing vessels include wounds and superficial injuries and bone fractures. Musculoskeletal diseases (hand or wrist tenosynovitis, bursitis of the elbow, bursitis of the knee, and epicondylitis of the elbow) and respiratory diseases (allergic rhinitis, chronic bronchitis, asthma), are examples of diseases that may result from performing maintenance operations without having adequate preventive measures in place.

Examples of hazards associated with routine or emergency maintenance activities and possible injuries and diseases are given below:

Equipment / system	Maintenance activity and associated hazards	Example of possible injury	Example of possible disease
Engine room	Greasing the equipment, changing the engine oil, repairing parts (hot pipes, toxic gases)	Superficial injuries, burns, scalds, acute poisoning	Skin, musculoskeletal and respiratory diseases, noise-induced hearing loss
Electrical installations	Operation and repair of electrical equipment (broken bulbs, exposed conductors, damaged insulation on power cords)	Burns, heart fibrillation, flashes, Electrocution	-----
Accumulator battery	Recharging batteries (risk of explosion by hydrogen gas ignited by a spark)	Multiple injuries	-----
Hauling gear, hoisting gear and related equipment	Contact with bare ropes and warps, broken cable strands and plain sharp edges	Superficial injuries, traumatic amputations	-----
Cooking and domestic appliances	Repairs to heating and cooking stoves (liquid propane gas)	Asphyxiation due to dangerous accumulation of gas	-----
Deck and ladders	Maintenance operations on the deck (e.g. falls through openings in the deck or into the stern trawlers ramp) or involving the use of ladders (trips and slips)	Bone fractures, multiple injuries, drowning (by falling overboard)	-----
Revolving shafts (propeller shafts and winch drums)	Repair and maintenance operations	Superficial injuries, concussion and internal injuries	-----

Equipment / system	Maintenance activity and associated hazards	Example of possible injury	Example of possible disease
Deck, accommodation, mechanical systems, steel components, hull	Repair operations involving fibreglass insulation, asbestos, chromates (working with chrome and stainless steel)		Skin, respiratory and malignant diseases
	Welding, soldering, brazing, and metal cutting (inhalation of solvents, gases and fumes)	Burns, scalds, eye burns (permanent loss of sight)	Eye irritation, metal poisoning, respiratory and musculoskeletal diseases
	Using chemicals, including solvents, paints, glues, polyester, epoxy resins and wood preservatives	Chemical burns (corrosions)	Respiratory, skin and malignant diseases
	Using flammable and combustible cleaning solvents	Burns as a result of a fire or explosion	-----
Refrigeration system	Repairs and maintenance operations exposed to refrigerants like ammonia and freon	Asphyxiation in a closed space, frost injuries	Respiratory diseases, liver damage, eye damage
Fish hold	Maintenance activities in fish holds, hold work, vessel salvage	Acute poisoning (gases produced by the decomposition of seafood)	-----
Dockside ladders or gangways	Boarding and leaving the vessel during dockside maintenance activities (trips and slips)	Superficial injuries, bone fractures, concussions and internal injuries	-----
Sewage systems	Cleaning activities in collection, holding, and transfer tanks involving sewage and human waste	Acute poisoning (toxic gases produced by the decomposition of human waste)	Respiratory diseases

Figure 2: Reading the maintenance plan before starting maintenance operations

Courtesy of INCDPN – The National Research and Development Institute on Occupational Safety, Romania

Hazards during maintenance operations on the deck and hull structure of vessels (dry-dock operations)

Major repairs on the hull structure of the boat or to the deck are performed in dry-dock and may include high-pressure washing, sandblasting, welding, soldering, brazing, burning, cutting, carpentry works and painting. The use of high-pressure cleaning equipment may produce high levels of noise, and toxic and/or corrosive cleaning solutions pose a risk if inhaled, or if skin or eye contact occur. Some tasks are associated with fall hazards (including falls from open deck edges). Particular types of risks may be posed by large and dangerous machinery operating in cramped spaces and the handling of heavy power tools.

Examples of typical dry-dock maintenance operations, associated hazards, and possible injuries and diseases are listed below.

Deck and hull - Major maintenance activity and associated hazards	Example of possible injury	Example of possible disease
Sandblasting operations	Superficial injuries, concussion and internal injuries (eyes)	Silicosis
Painting, roofing and decking systems (paints, surface coatings, some glues, sealants, degreasers)	Chemical burns (corrosions)	Respiratory, skin and malignant diseases
Welding, soldering, brazing, burning, cutting (zinc, copper or iron fumes)	Burns (thermal), eye burns (permanent loss of sight)	Eye irritation, metal poisoning, respiratory diseases
High-pressure washing / cleaning equipment (high-pressure steam or uncontrolled hoses)	Traumatic amputations, wounds and superficial injuries, burns and scalds (thermal), eye injuries	Infections from water and debris trapped under the skin, noise-induced hearing loss
Insulation works, plumbers and pipefitters (asbestos, glass wool, fibreglass)	-----	Asbestosis, allergic skin reactions, respiratory, musculoskeletal and malignant diseases
Carpentry, painting (pentachlorophenol or penta, cuprinol, creosote or inorganic arsenicals)	Chemical burns (corrosions)	Eye irritation, respiratory and malignant diseases

Preventive measures

Specific preventive measures to control the risks during maintenance activities should be based on an adequate risk assessment. Some examples are listed below.

Maintenance in dry-docks:

- The vessel's OSH management system should also cover maintenance in dry-dock. Docking introduces hazards not normally encountered when the vessel goes about day to day business, generating the need for additional risk assessments.
- Ships' crews, yard workers and contractors are often at risk from hazards that the shared workplace creates. While permanent yard staff may be adequately trained, contractors and the

crew may not be fully aware of the hazards at the shipyard. The shipyard needs to provide information and instruction to all persons who will be directly or indirectly exposed to potential hazards. Adequate coordination and communication is key to ensuring that the activities of the yard, contractors and ship's crew do not increase the risks to anybody present at the workplace.

Hazardous substances

- Hazardous substances should be kept in their original containers. Where this is not possible, the substitute containers should be clearly labeled. Hazardous substances should never be stored in food or drink containers.
- When working with glues, sealants, paint solvents and pigments, primer, coating, epoxy resins, cleaners, isocyanates, solvents, degreasers, metal cleaners, wood preservatives, and any other hazardous substances, read the label and the product's Material Safety Data Sheet (MSDS). Wear the appropriate personal protective equipment and work only in well-ventilated areas.
- Ammonia, freon and halon are found in refrigerator units, pumps and lines; appropriate breathing apparatus should be worn and gas detection devices should be used before entering an area where there is a system with a problem.
- Carbon monoxide, nitrogen dioxide and sulphur dioxide are byproducts of combustion, most common in confined spaces with poor ventilation; galley areas and engine rooms should be well ventilated and carbon monoxide levels should be tested regularly by using air quality monitors. Methane and hydrogen sulphide gases are produced by rotting fish; test air quality or enter a hold wearing a breathing apparatus.
- Silica should not be used in sandblasting operations. An approved respirator must be worn by the operator carrying out sandblasting, and the workplace must be well ventilated.

Fire and explosion hazards

- Many of the maintenance activities can increase the risk of fire. The ways to minimise the risk of fire should be considered when planning the work. Measures can include:
  - Good housekeeping
  - Replacing flammable and highly flammable materials with less flammable substitutes
  - Minimising the quantities of combustible, flammable and highly flammable materials such as paper, paints, petrol and thinners and ensuring they are appropriately stored
  - Remember where flammable vapours exist, electrical equipment including battery operated tools could ignite the vapour.
  - Removing all flammable waste materials from site at the end of each working day and dispose of it in accordance with manufacturer's recommendations.
- Fuel vapours, methane and liquid propane gas are explosive and may be found near fuel sources, galley and engine room; any smell must be reported immediately. Hydrogen is explosive and found wherever lead-acid batteries are charged or hydrogen gas cylinders are used or stored; all sources of ignition, including electrical sparks, must be kept away from recharging lead-acid batteries.

Confined spaces

- Vessels have numerous confined spaces such as holds, tanks, compartments, cofferdams, double bottoms, bilges and galleys. Confined spaces may be susceptible to a build up of flammable or noxious gases or a lack of oxygen. There is the possibility that anyone working in the confined space could be:

- Overcome by gas, fumes, vapours or lack of oxygen
- Drowned by water or free-flowing solids
- Injured due to fire or explosion
- Overcome by high temperature

- It is essential that the potential hazards associated with each confined space are fully appreciated, and that the appropriate planning and preparation for the work is undertaken. Before entering a confined space, the air must be tested with gas measuring instruments, with an explosimeter (gas concentration meter) or with a gas detector, and it should be monitored during the work. Confined spaces should be entered only by competent persons wearing approved breathing equipment (self-contained breathing apparatus). Only approved explosion-proof safety lamps with their own sources of electrical power should be used. The use of open flames, electrical tools and cable lamps should be permitted only if it has been confirmed that they are gas-free.

Electrical installations

- Vessel electrical and grounding systems tend to be complex. Maintenance of electrical installations should always be carried out by a qualified electrician.
- When repairing AC systems, ensure that outlets have ground fault interrupter (GFI) devices, wear rubber boots, knee pads, gloves and a plastic hard hat; use only power tools and electrical cords with the three-prong plug that indicates a grounded system.

Working at height

- Work at height does not only encompass working from a ladder or on scaffolding but may also include: working alongside an open hatch or other opening in a vessel's structure, working in close proximity to the vessel's side, and so on. If work at height cannot be avoided, it has to be properly planned. Planning should include the carrying out of a risk assessment. When working close to unfenced edges or at a height of over two metres, a safe working platform should be erected. If this is not possible, safety harnesses should be used.
- Weather conditions should be taken into account. Work at height should be only carried out on board when weather conditions do not jeopardise the health and safety of workers.

Personal protective equipment

- Personal protective equipment is the last resort, and they are required in most maintenance activities. For example, boiler suit, work boots, gloves, hard hat and ear protection during engine room activities; safety goggles, rubber gloves, apron and work boots during battery maintenance activities; adequate respirators (especially self-contained breathing apparatus) if asbestos-containing materials are sanded, cut, drilled or removed; protective clothing and the correct respirator (air-purifying respirator full or half face mask) when painting, welding or carrying out sheet metal work with chromates, chrome or chromium.

Figure 3: Maintenance operations on the main engine

Courtesy of INCDPN – The National Research and Development Institute on Occupational Safety, Romania

Maintenance on fishing vessels and safety and health management

▪ *Pre-sailing checks or inspections*

A thorough pre-sailing check of critical equipment/machinery, tools and procedures of the vessel prior to leaving the dock helps to avoid accidents at sea that may lead to severe vessel damage, or even the loss of the vessel and loss of life, and will reduce the need for emergency repairs while at sea [9][10].

Equipment	Pre-sailing check
Mechanical and electrical parts	The ship must be supplied with all necessary components, products, equipment and basic spare parts.
Fire fighting	Fire detection and fire fighting equipment and alarm systems must be checked.
Lifesaving equipment	The ship's lifesaving equipment must be checked and correct in accordance with requirements (for example, life jackets, buoyancy aids, immersion suits, inflatable life raft, small boats or skiffs, distress flares and MOB (man overboard) markers, EPIRB).
Vessel's structure	▪ The ship must be in a satisfactory condition of stability and may not exceed the limits specified in the ship's documentation; ▪ The vessel's structural condition must be satisfactory; ▪ All doors, hatches, and openings critical to the vessel's watertight integrity must be closed prior to departure.
Navigation and transmission equipment	Perform a complete operational check before first departure each day (in some cases, confirmation of this check must be noted in the ship's logbook): ▪ radar; ▪ GMDSS (global maritime distress and safety system); ▪ navigation lights, shapes, sound signal appliances; ▪ radio communications equipment (VHF radio), including the compulsory speaker on the aft deck of a fishing ship.

Equipment	Pre-sailing check
Steering Engine controls	Steering gear and engine controls must be checked, to ensure they are in good working condition.
Propulsion and transmission equipment Bilge pumps	The following equipment, and any other relevant equipment, must be checked and regularly serviced in line with the manufacturer's instructions: ▪ engines and remote alarms; ▪ generator; ▪ engine gearbox.
Electrical equipment	▪ emergency electrical power source; ▪ accumulator battery as an emergency electrical power source; ▪ emergency electrical fire pump; ▪ emergency lighting.
Other equipment	▪ anchoring equipment; ▪ compressed air systems; ▪ bilge pumps and remote alarms.

▪ *Safe maintenance on fishing vessels*

Essential principles to assure safe and effective maintenance operations on board fishing vessels are outlined below [11].

- Maintenance operations must be integrated into the **OSH management** of the fishing vessel. A comprehensive OSH management system should cover routine and emergency maintenance while at sea but take also into account major repairs in wet dock and periods spent in dry-dock.
- Having a **maintenance programme** is very important so that maintenance is carried out in a regular and systematic way, in order to avoid emergency corrective maintenance. It should include inspections and safety checks.
- Maintenance should start with **proper planning** of the operations. Formal risk assessments should form the basis for safe work procedures. The time and resources required and the competence of workers must be considered.
- It is essential to **involve the crew** in the risk assessment and maintenance management process:
  - by providing information regarding planning and scheduling of operations;
  - by providing adequate training on hazard identification, maintenance procedures and special working permits;
  - by consultation and participation of maintenance workers in the risk assessment of maintenance operations.
- **Appropriate equipment** must be used, including tools and personal protective equipment (PPE).
- The vessel's crew must receive **training**, including OSH training, which should be periodically reviewed and kept up to date with technical developments. For example, training may be provided in the following areas [12]:
  - Maintenance and repair of fishing gear;
  - Maintenance and repair of steam or internal combustion (petrol or diesel) engines;
  - Care of radio and radar installations;

- Maintenance and repair of refrigeration systems, fire-fighting equipment, deck and trawling winches and other mechanical equipment on fishing vessels;
- Maintenance and repair of the electrical machinery and equipment of fishing vessels.

OSH management of maintenance operations on fishing vessels must include record keeping of:

- maintenance work, periodic inspections and monitoring and safety audits;
- Records of equipment defects, accidents and injuries and other incidents at sea which affect or could affect the safety and health on board.

Relevant EU legislation

Health and safety requirements for fishing vessels are laid down in European and international legislation and are enforced at national level. The most relevant directives include:

Council Directive 93/103/EC

concerning the minimum safety and health requirements for work on board fishing vessels (thirteenth individual Directive within the meaning of Article 16 (1) of Directive 89/391/EEC).
http://osha.europa.eu/en/legislation/directives/sector-specific-and-worker-related-provisions/osh-directives/13

Council Directive 89/391/EEC

on the introduction of measures to encourage improvements in the safety and health of workers at work – Framework Directive which contains the general principles of prevention, lays down employers' obligations concerning the assessment of risks, the elimination of risks and accident factors, the informing, consultation and balanced participation and training of workers and their representatives.

http://osha.europa.eu/en/legislation/directives/the-osh-framework-directive/1

For more information on European legislation:

http://osha.europa.eu/en/legislation

Further information regarding risk assessment on fishing vessels

European Agency for Safety and Health at Work (EU-OSHA). HWI Risk assessment checklists
http://osha.europa.eu/en/campaigns/hwi/ra_tools_generic/

Guidance on risk assessment at work. European Commission, 1996
http://osha.europa.eu/en/topics/riskassessment/guidance.pdf

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http://osha.europa.eu/en/campaigns/hwi/about/material/rat2007

Risk assessment – your ticket to safety on board. Sjøfartsdirektoratet, Norwegian Maritime Directorate
http://www.dieselduck.net/machine/06%20safety/2004%20NCG%20Risk_Assessment.pdf

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http://www.seafishmarineservices.com/Safety%20Folder/Safety%20Folder%20May%2007%20(complete).pdf

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- ***Further information regarding safe maintenance on fishing vessels***

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http://www.tc.gc.ca/eng/marinesafety/tp-tp10038-46-eai-bilge-instal-mainten-516.htm

Factsheet 38, European Agency for Safety and Health at Work (EU-OSHA).
http://osha.europa.eu/en/publications/factsheets/38/view

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http://www.hsa.ie/eng/Publications_and_Forms/Publications/Fishing/Fishing_Vessel_SS.pdf

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The Marine Accident Investigation Branch (MAIB). Safety Digests Fishing. Lessons from Fishing Accident Reports
http://www.maib.gov.uk/publications/safety_digests/safety_digests___fishing.cfm

MSA -Marine Safety Agency. MGN 20 (M+F). Implementation of EC Directive 89/391.
http://www.mcga.gov.uk/c4mca/mgn0020.pdf

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Seafish. Risk Assessment Safety Folder – http://www.seafish.org/sea/safety.asp

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